Optimization of a Fully-Passive Neurosensor for Recording Neural Activity of a Free-Moving Animal: Characterization of Rat Skin Dielectric Properties

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Systems and sensors for monitoring neural activation are essential for studying neurological disorders. Existing neuropotential acquisition systems are typically highly-invasive, end up with protruding from the scalp, and leaving patients susceptible to infections. To address these pitfalls, in recent papers we proposed a novel fully-passive and fully-implantable neurosensing system, consisting of an implanted sensor and radiator, interrogator transceiver, and neural probes along with a demodulation circuits within the implant (C. Lee, A. Kiourti, J. Volakis, IEEE Antennas and Wireless Propagation Letters, Vol. 16, 2017). Previous experiments demonstrated neural signal sensitivity of approximately -135 dBm, implying signal detection down to 25μV or even lower. Recently developed probes also allowed for *in vivo* validation of this device that included a series of electrophysiological recordings of spontaneous cardiac activity and evoked epileptic neural activity. A critical development to achieving these recordings was the low-impedance of the neural probes, specially designed for the neurosensing system (C. Moncion, S. Bojja-Venkatakrishnan, J.R. Diaz and J.L. Volakis, IEEE IMBioC, pp. 76 – 78, 2018).

A next step to the aforementioned tests is the study on a free-moving animal model with induced epilepsy to continuously record neural activity. Before a fully-implanted animal study can be done, a detailed characterization of the dielectric properties of the rat's skin is necessary. Of particular interest is the variation of the dielectric properties when the rat is in motion to ensure impedance matching and continuous tuning for optimal signal transmission through the rat's skin.

At the conference, we will present results of a characterization using a thru-reflect-line (TRL) measurements. For this experiment, a 20 x 20 mm skin sample from the top of the head (the region below which the implant will be placed) was obtained from an anesthetized rat. Afterwards, using a vector network analyzer (VNA) we measured the scattering parameters of the skin placed in the fixture. The parameters within the DUT were deembeded and used to estimate the corresponding permittivity and conductivity values from 2 - 6 GHz. Upon consideration of these dielectric values, the neurosensing system was retuned to provide for unobtrusive recording of neural activation in animal models.